A Computational Study to Determine the Critical Velocity Required to Initiate Explosively Loaded Munitions

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OUTLINE

- BACKGROUND
- OBJECTIVES
- PROJECTILES
- TARGETS
- CODE
- MODEL
- RESULTS
- CONCLUSIONS

OBJECTIVES

- **UNDERSTAND THE EFFECTS OF DIFFERENT TYPES OF COVER PLATES ON THE INITIATION PROCESS**
- **ASSESS THE VULNERABILITY OF MUNITIONS AGAINST VARIOUS TYPES OF THREATS**
- **PREVENT THE COMMUNICATION AMONG THE MUNITION ROUNDS**
- **DETERMINE CRITICAL VELOCITY**

BACKGROUND

- **STRONG SHOCK BY THE PROJECTILE IMPACT CAN DETONATE EXPLOSIVE IN THE MUNITIONS**
  - **SHOCK MAGNITUDE AND DURATION VERY IMPORTANT**
- **PROJECTILE DIAMETER AND IMPACT VELOCITY MAIN PARAMETERS**
- **LARGE DIAMETER PROJECTILE MORE EFFECTIVE INITIATING THE EXPLOSIVE**
- **CONDITIONS FOR SHOCK-TO-DETONATION TRANSITION DESCRIBED BY JACOBS-ROSLUND EQUATION**

BACKGROUND

- **RESPONSE OF HIGH EXPLOSIVE TO PROJECTILE IMPACT IMPORTANT TO ASSESS VULNERABILITY OF MUNITIONS**
- **THICKNESS OF THE COVER PLAYS A SIGNIFICANT ROLE IN PREVENTING THE REACTION**
- **CRITICAL VELOCITY PRINCIPALLY A FUNCTION OF THE PROJECTILE'S DIAMETER**
- **CRITICAL VELOCITY: MIN VEL OF THE PROJ TO DETONATE THE EXPLOSIVE**

JACOBS-ROSLUND EQUATION

$$V = A/d^{0.5}(1+B)[1+CT/d]$$

A: Constant based on the sensitivity of the impacted explosive to shock compression

B: Constant based on the projectile nose shape

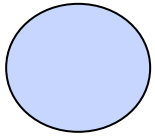
C: Cover material constant

d: Diameter of the projectile

T: Cover plate thickness

V: Critical velocity to detonate the explosive

PROJECTILES



SPHERE

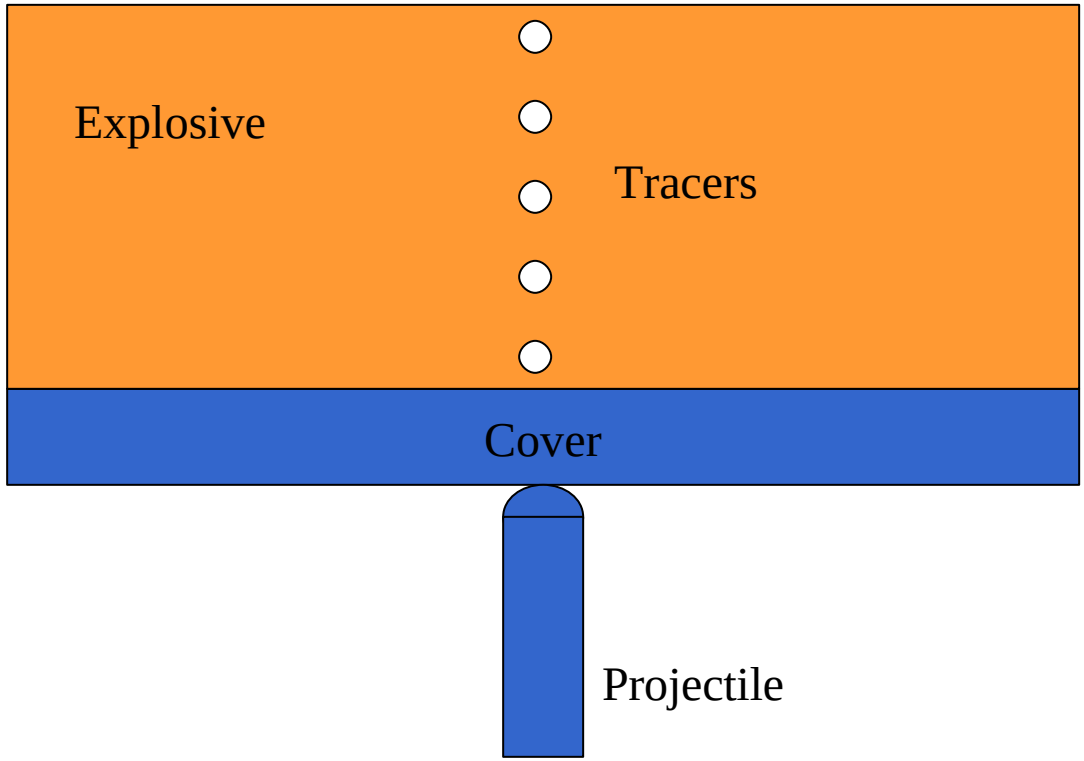
CYLINDERICAL
HEMI-NOSE

CYLINDERICAL
FLAT-NOSE

CYLINDRICAL
POINTED-NOSE

DIAMETER: 5 - 15 mm, LENGTH: 25.4 - 100 mm

Projectile Impacting the Target



CTH AND HVRB

- **DEVELOPED BY SANDIA NATIONAL LABORATORY**
- **FINITE DIFFERENCE ANALOGS OF LAGRANGIANS EQUATIONS**
- **CAPABLE OF MODELING DYNAMICS OF**
  - **MULTIDIMENSIONAL SYSTEMS**
  - **MULTIPLE MATERIALS, LARGE DEFORMATIONS AND STRONG SHOCK WAVES**
- **USES MIE-GRUNEISEN, JWL AND SESAME EOS, JOHNSON-COOK, AND ZERILLI-ARMSTRONG MODELS**

CTH AND HVRB

- **THREE REACTION AND TWO POROSITY MODELS**
- **HVRB IS ONE OF THE THREE REACTION MODELS**
- **HVRB DESIGNED TO TREAT PROCESS OF INITIATION OF DETONATION IN HE**

CONFIGURATIONS

Cover	h/d	Projectile
h		d
mm		mm
1.250	0.2500	5.00
2.500	0.5000	5.00
5.000	1.0000	5.00
2.250	0.2250	10.00
5.000	0.5000	10.00
10.000	1.0000	10.00
3.750	0.2500	15.00
7.500	0.5000	15.00
15.000	1.0000	15.00
4.763	0.1875	25.40
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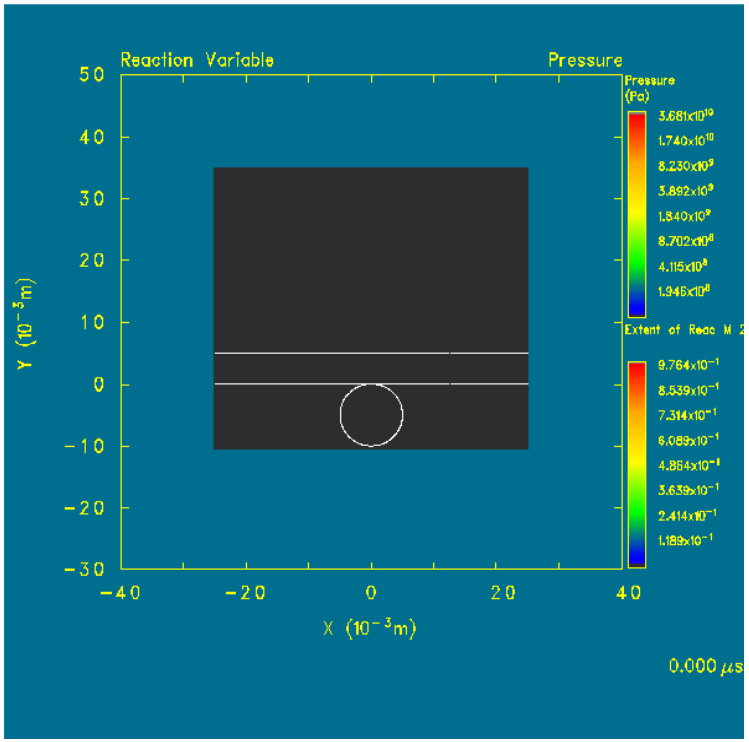
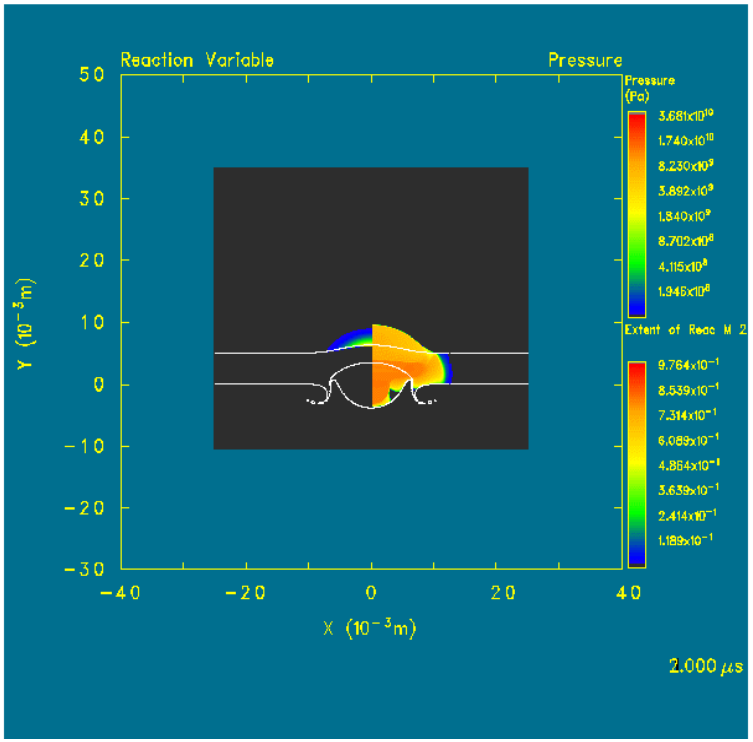
Pressure and Reaction Variable Contour Plots

Weapons & Materials Research Directorate *Terminal Effects Division*





5-mm Spherical Projectile at 3.1-mm/μs

Impacting Comp B with 5-mm cover

Pressure and Reaction Variable Contour Plots

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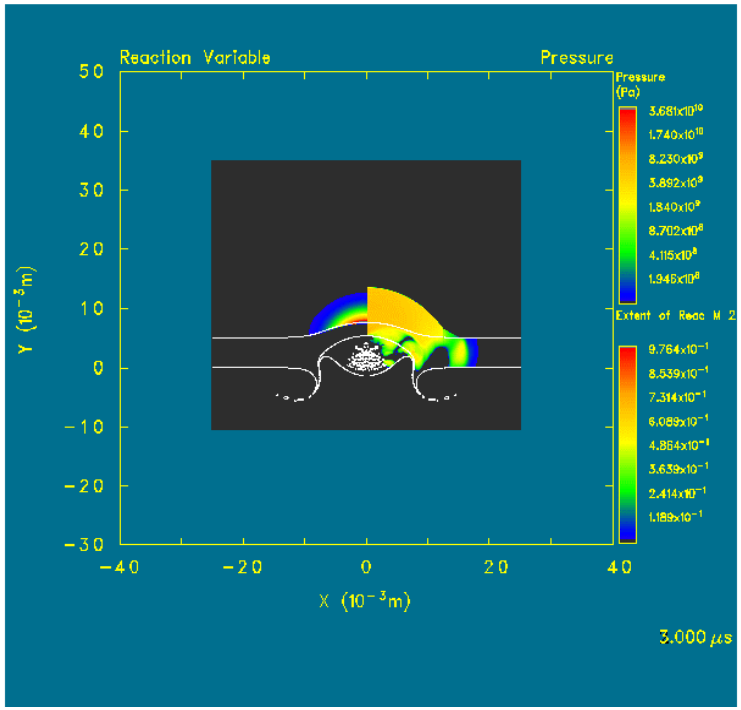

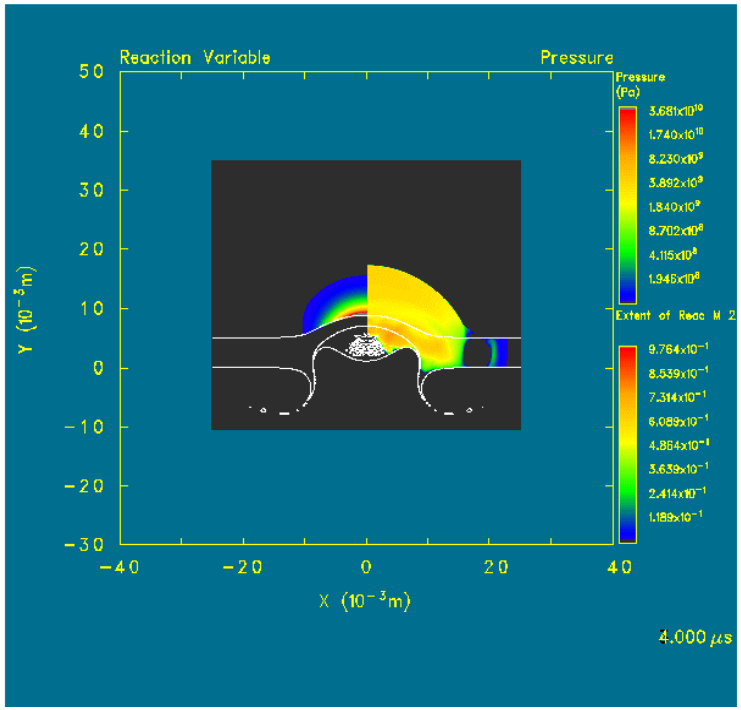

5-mm Spherical Projectile at 3.1-mm/μs

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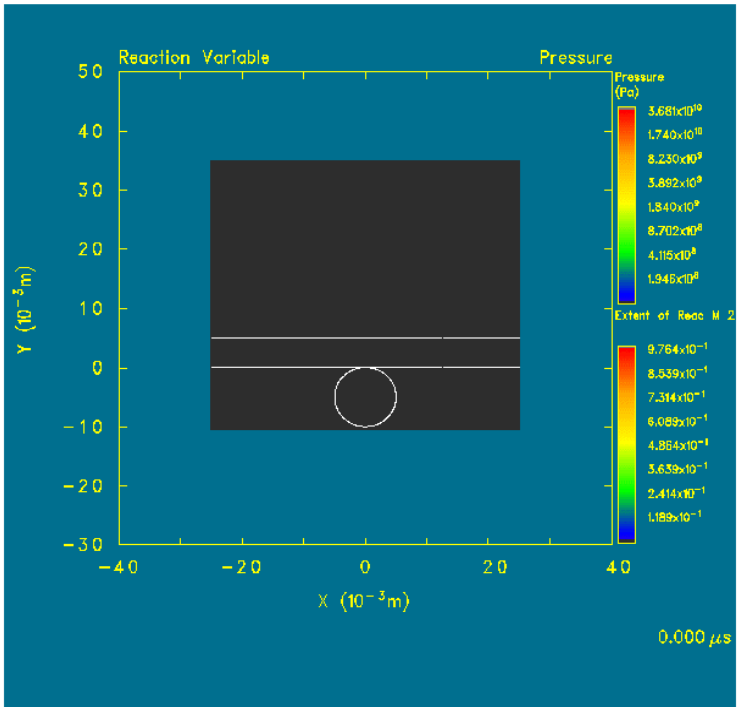

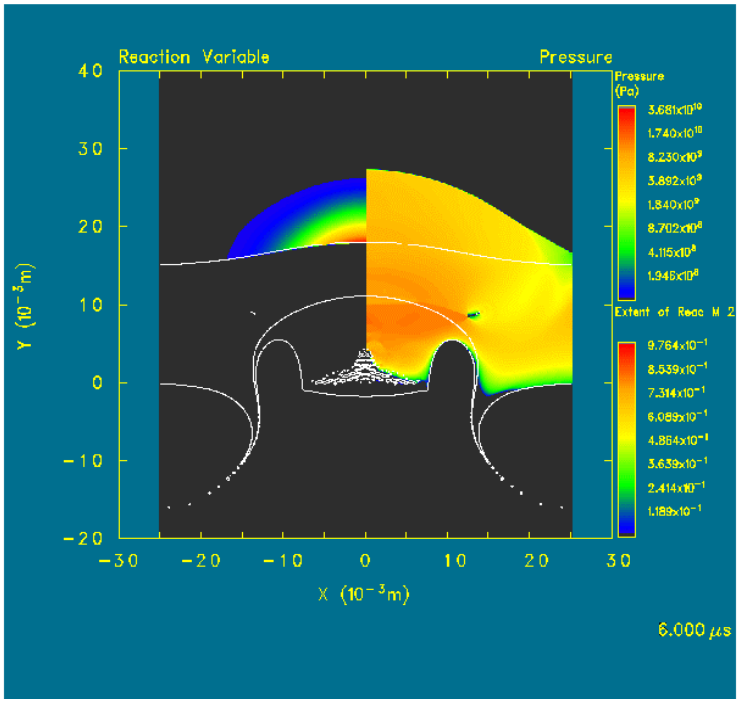

5-mm Spherical Projectile at 3.2-mm/μs

Impacting Comp B with 5-mm cover

Pressure and Reaction Variable Contour Plots

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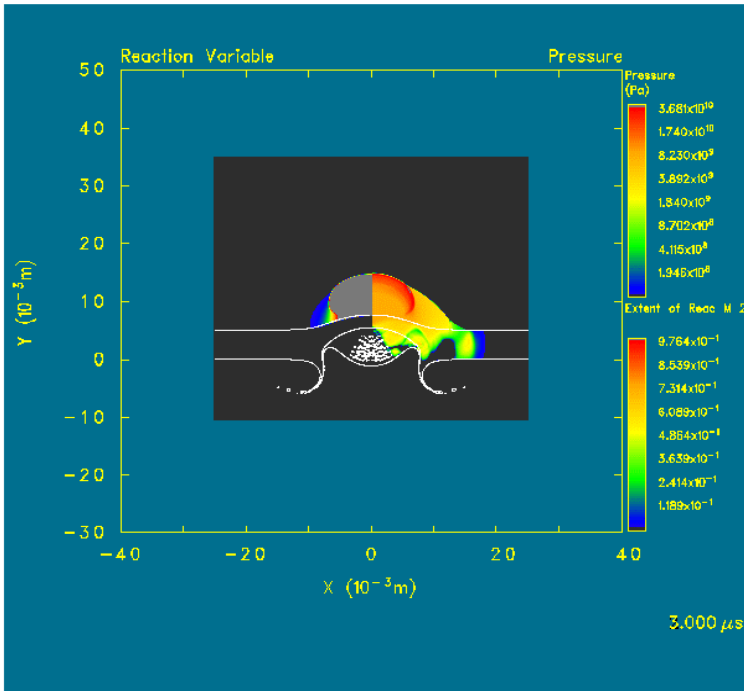
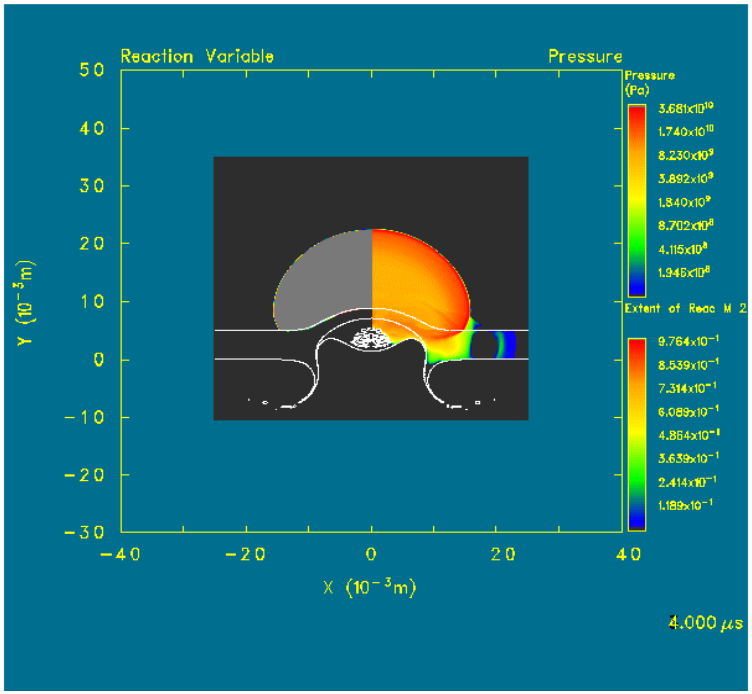
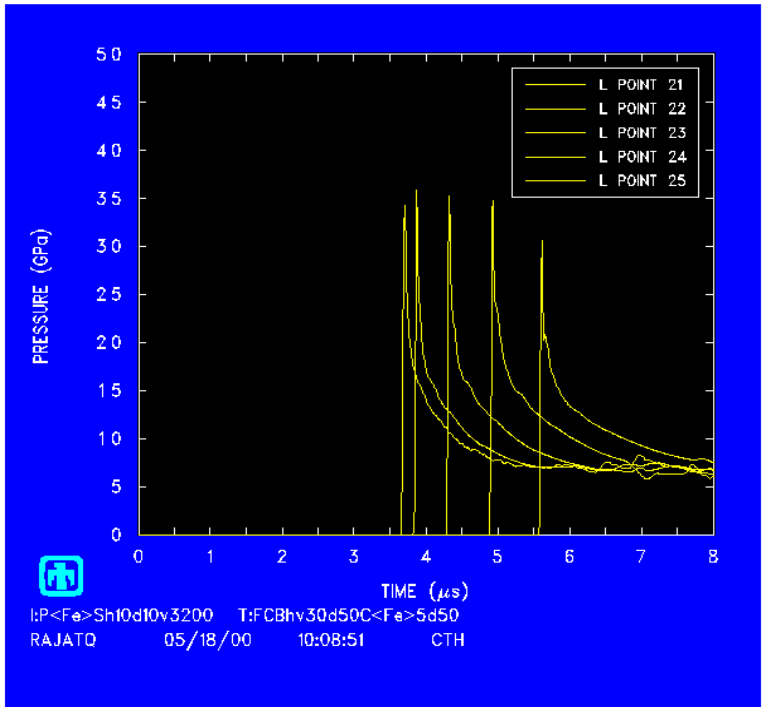


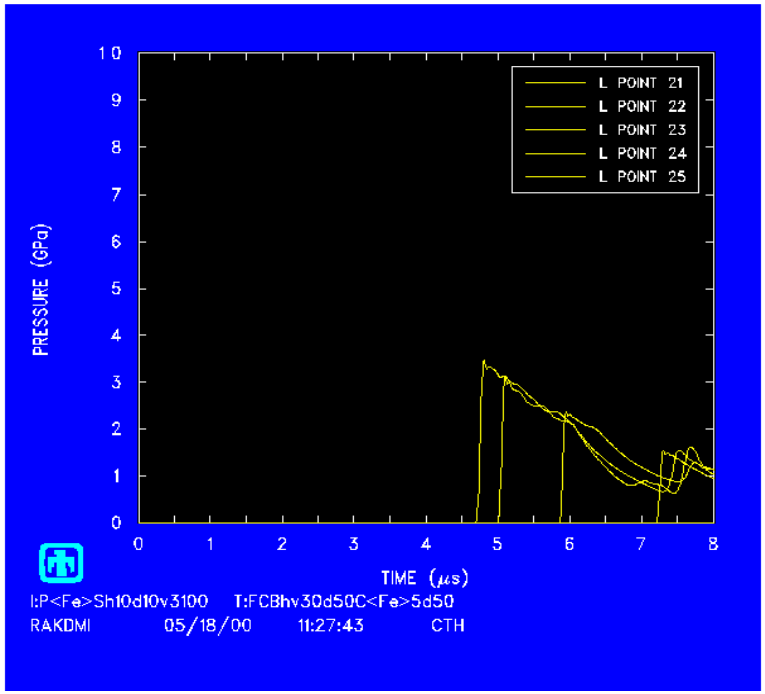


5-mm Spherical Projectile at 3.2-mm/μs

Impacting Comp B with 5-mm cover

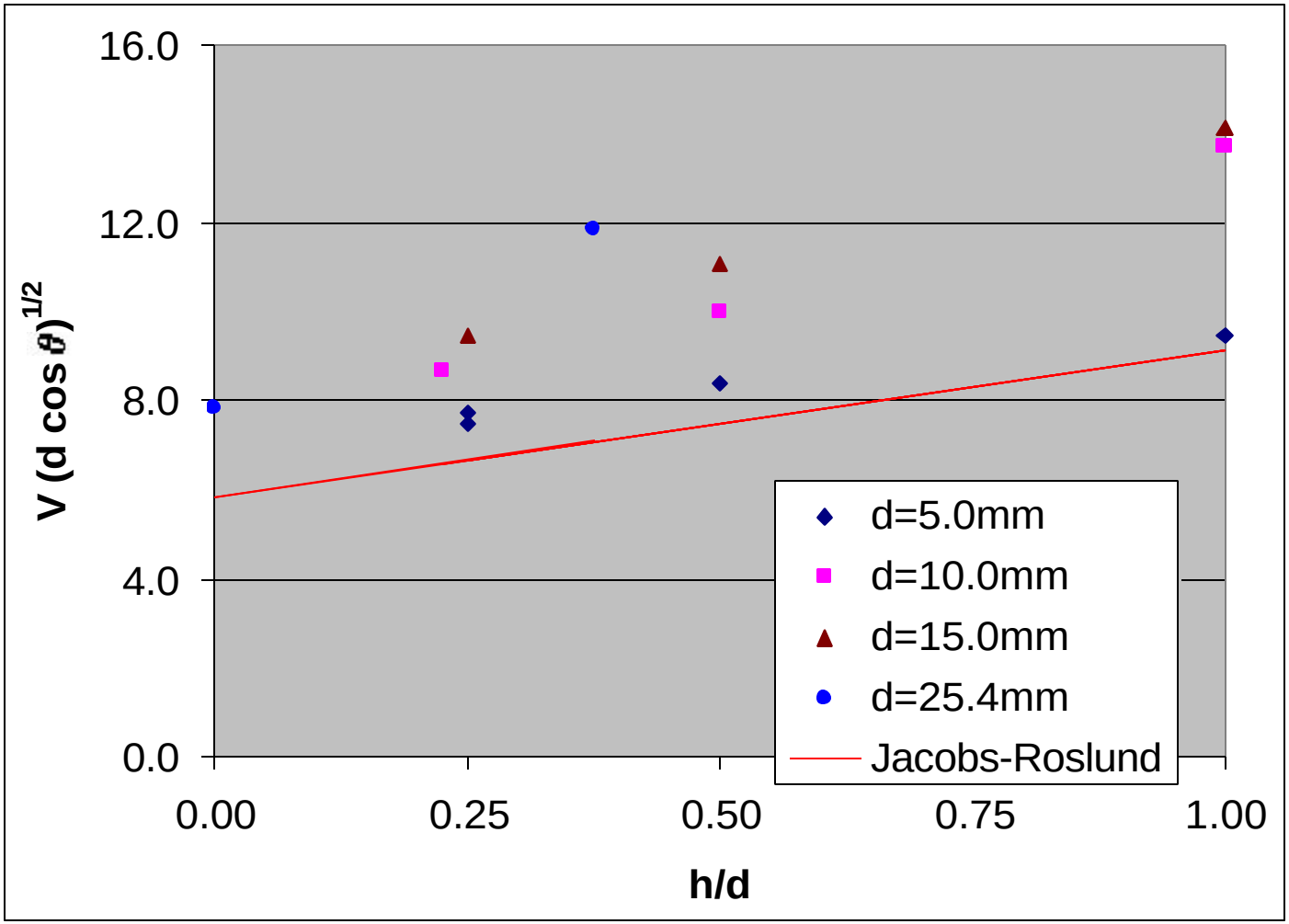
Pressure Time History Plots





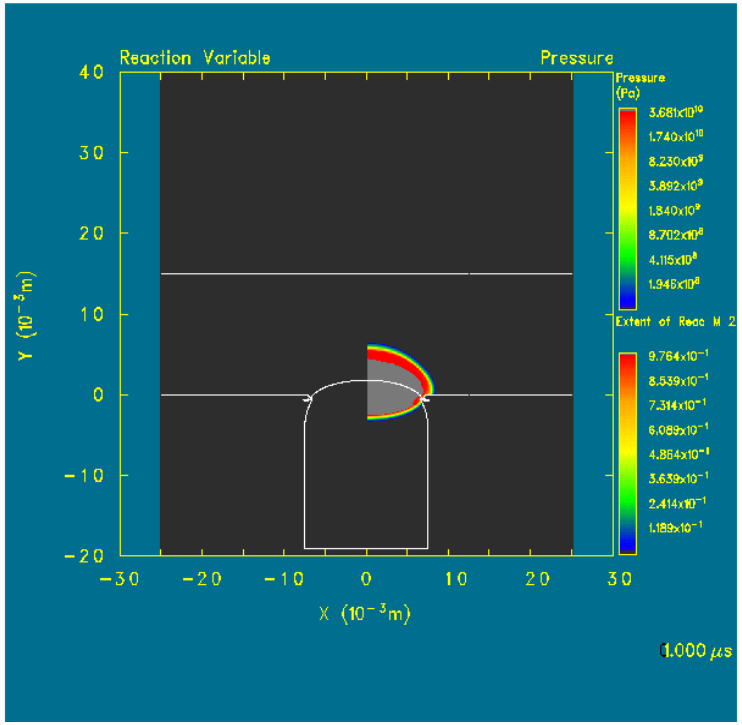
5-mm Spherical Projectile at 3.2-mm/μs (left) and 3.1-mm/μs (right) Impacting Comp B with 5-mm cover

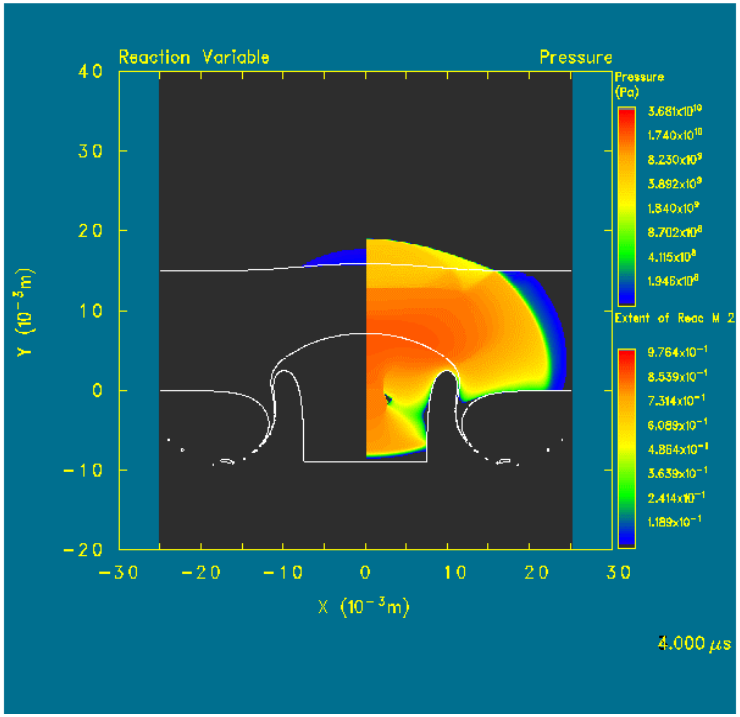
CRITICAL VELOCITY AS A FUNCTION OF h/d



Pressure and Reaction Variable Contour Plots

Weapons & Materials Research Directorate *Terminal Effects Division*



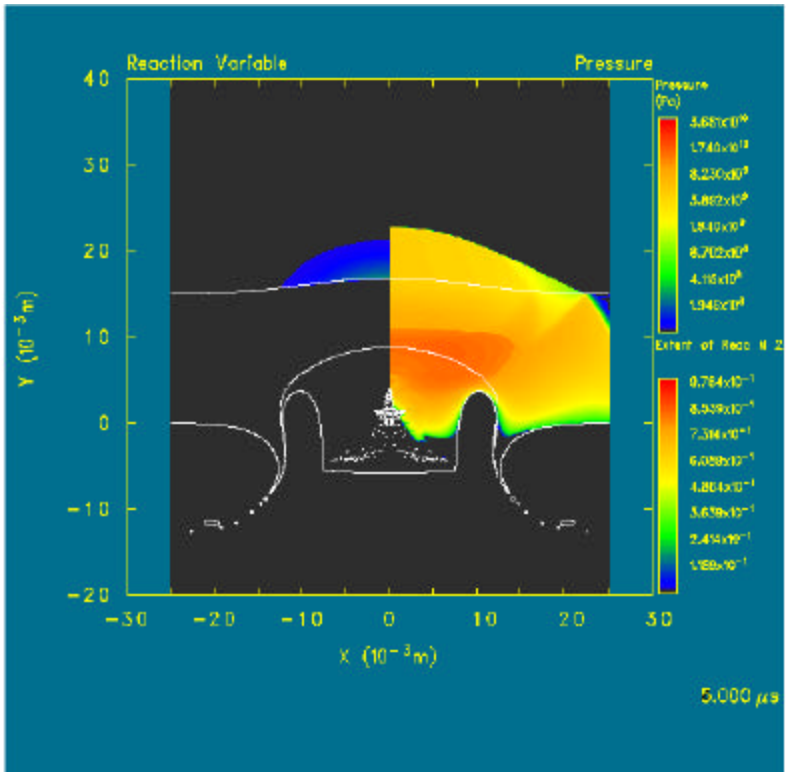


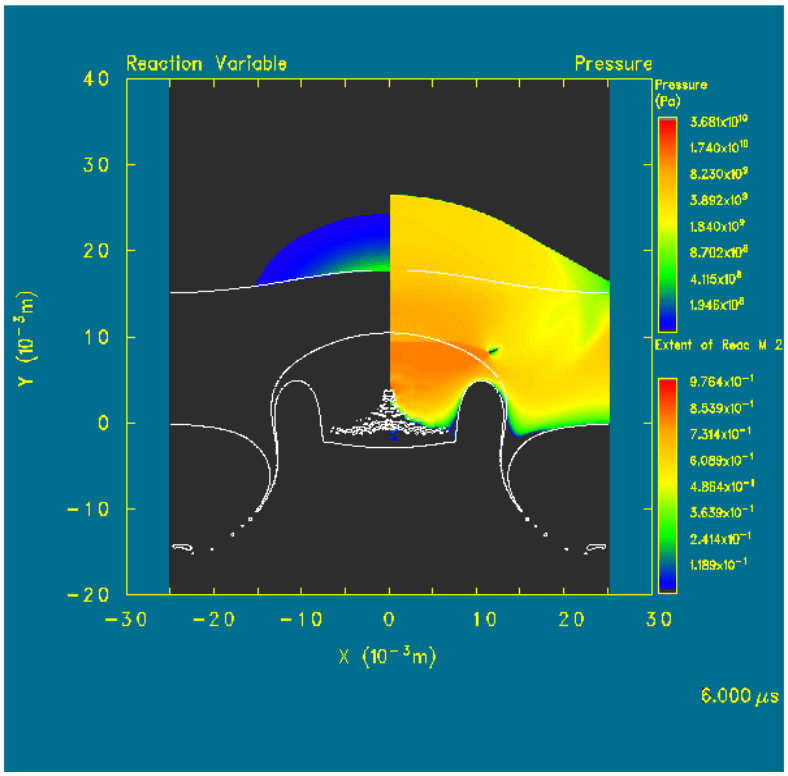
15 mm Cylindrical Projectile at 3.6-mm/µs

Impacting Comp B with 15-mm cover

Pressure and Reaction Variable Contour Plots

Weapons & Materials Research Directorate *Terminal Effects Division*

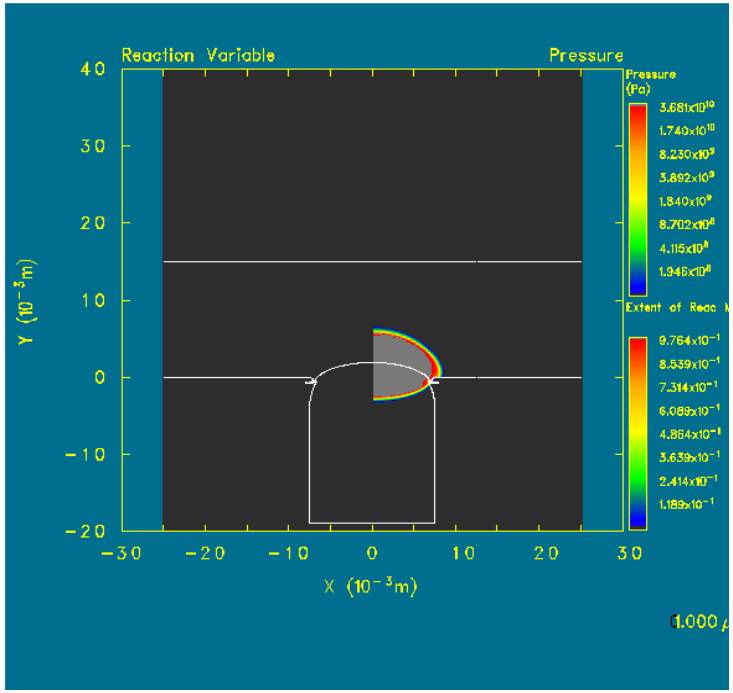


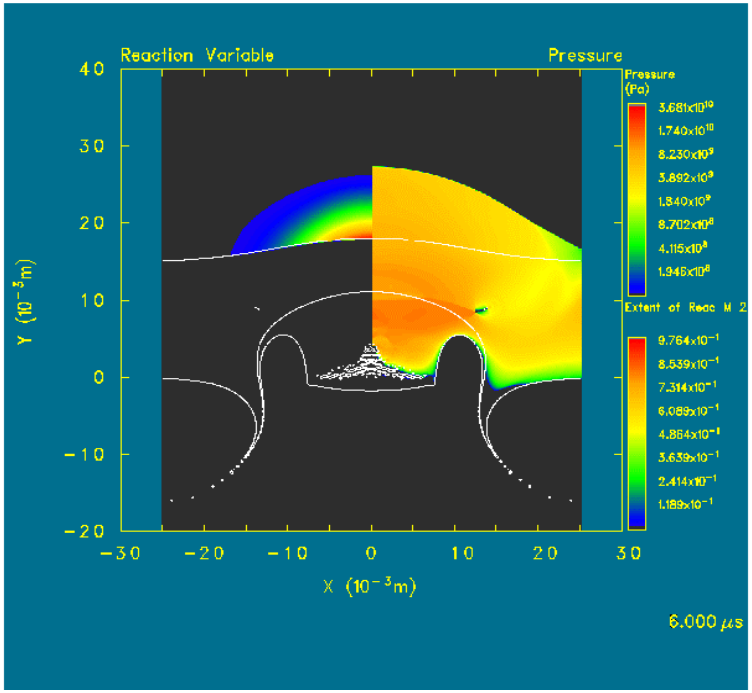


15-mm Cylindrical Projectile, at a vel of 3.6-mm/μs,
Impacting Comp B with 15-mm cover

Pressure and Reaction Variable Contour Plots

Weapons & Materials Research Directorate *Terminal Effects Division*



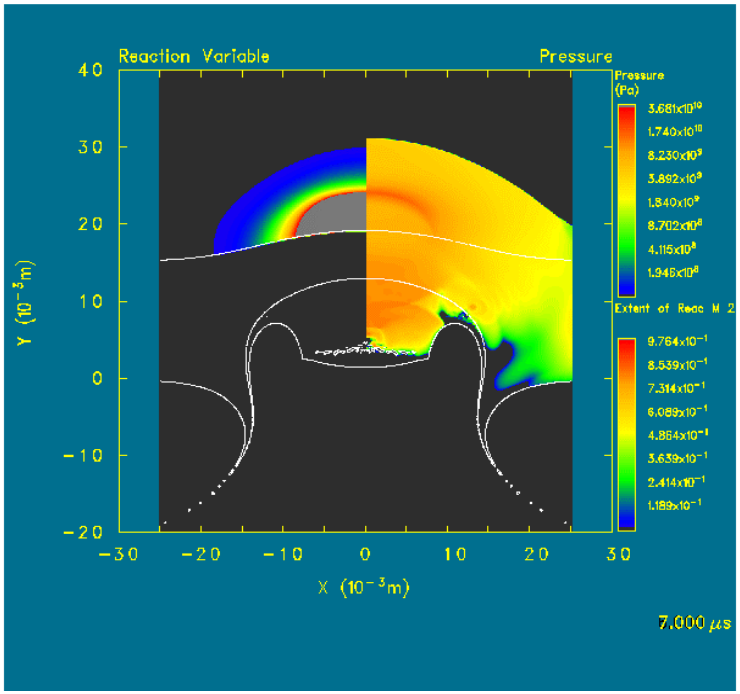


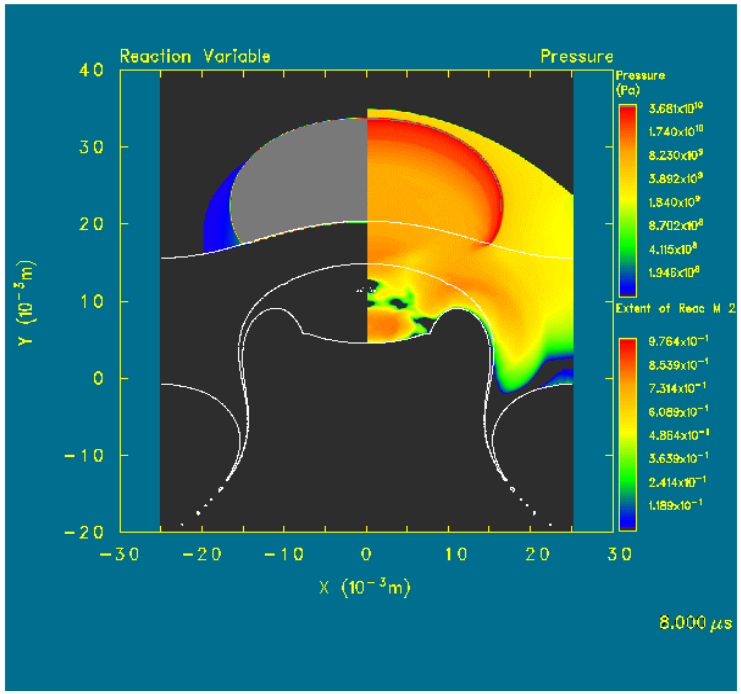
15-mm Cylindrical Projectile at 3.7-mm/μs

Impacting Comp B with 15-mm cover

Pressure and Reaction Variable Contour Plots

Weapons & Materials Research Directorate *Terminal Effects Division*

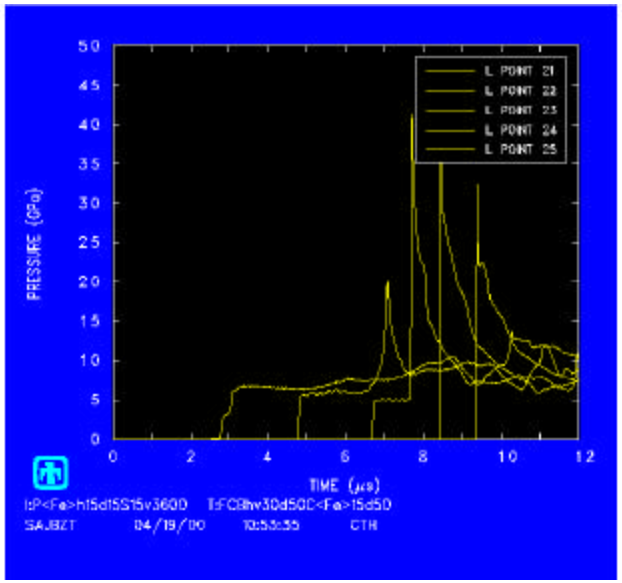


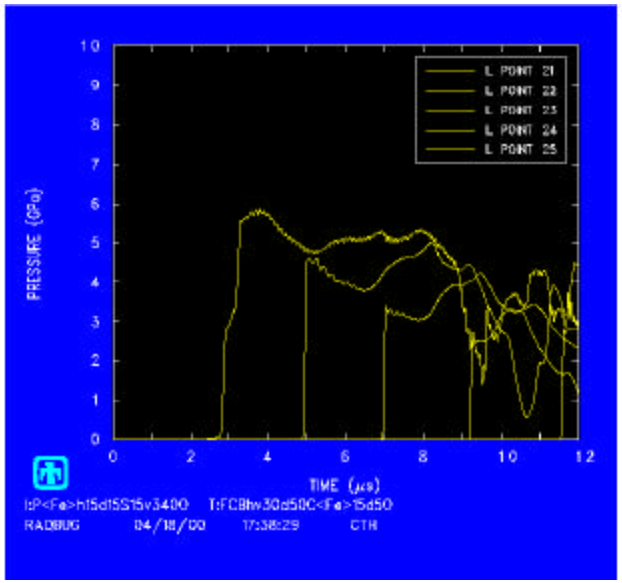


15-mm Cylindrical Projectile at 3.7-mm/μs

Impacting Comp B with 15-mm cover

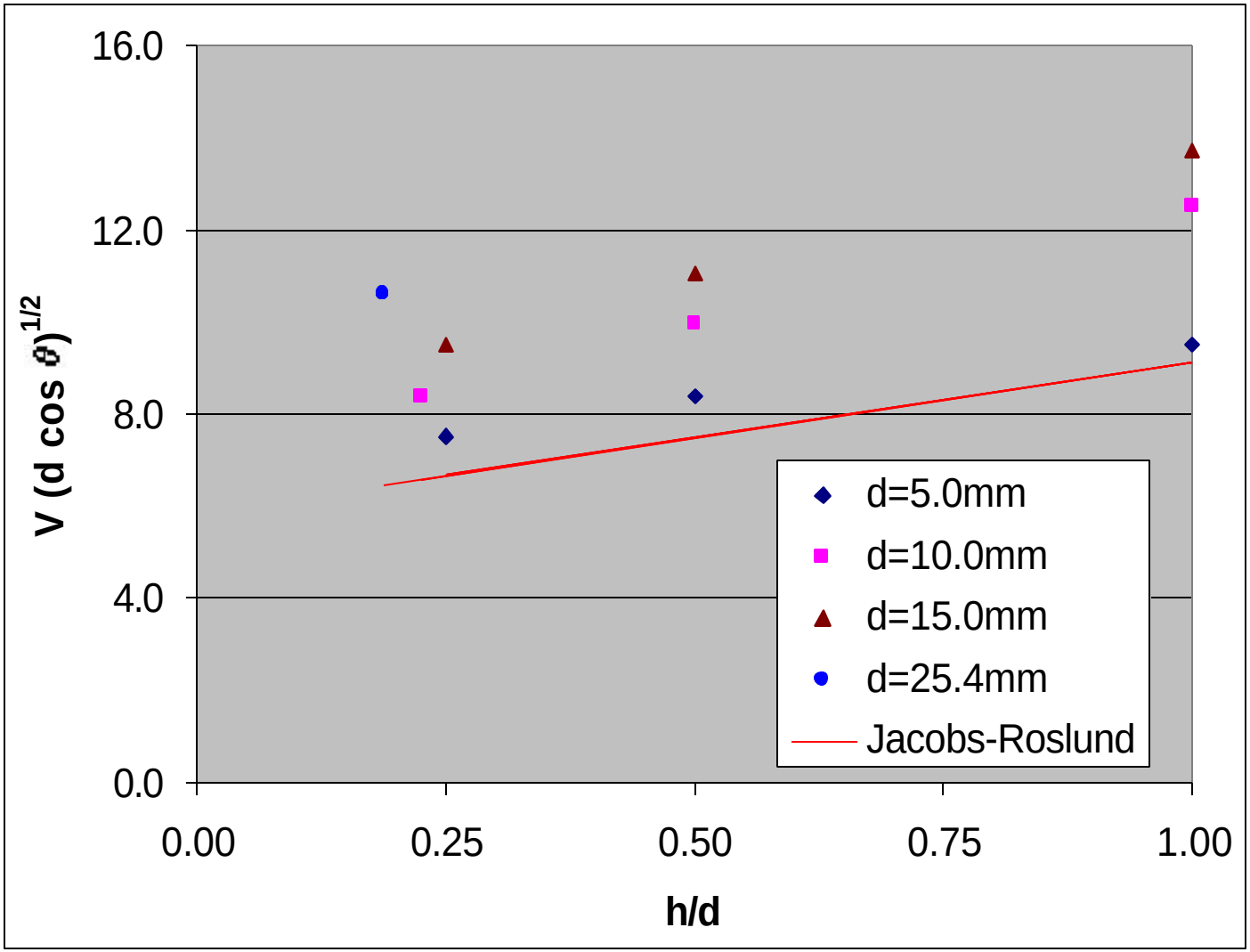
Pressure Time History Plots





15-mm Cylindrical Projectile at 3.7-mm/μs (left) and 3.6-mm/μs (right) Impacting Comp B with 15-mm cover

CRITICAL VELOCITY AS A FUNCTION OF h/d



COMPARISON OF COMPUTED AND PREDICTED VELOCITIES

Cover		Projectile				Zoning
h	h/d	d	q	V_c	mm/μs	
mm		mm	°	CTH	J-R	mm
1.250	0.2500	5.00	0	3.35	2.98	0.1
2.500	0.5000	5.00	0	3.75	3.35	0.1
5.000	1.0000	5.00	0	4.25	4.08	0.1
2.250	0.2250	10.00	0	2.65	2.08	0.1
5.000	0.5000	10.00	0	3.15	2.37	0.1
10.000	1.0000	10.00	0	3.95	2.89	0.1
3.750	0.2500	15.00	0	2.45	1.72	0.1
7.500	0.5000	15.00	0	2.85	1.93	0.1
15.000	1.0000	15.00	0	3.55	2.36	0.1
4.763	0.1875	25.40	0	2.10	1.28	0.1
4.763	0.1875	25.40	0	2.10	1.28	0.2
4.763	0.1875	25.40	0	2.10	1.28	0.4

CONCLUSIONS

- RELATIONSHIP BETWEEN IMPACT VELOCITY OF PROJECTILE AND THICKNESS OF COVER
- RELATIONSHIP BETWEEN IMPACT VELOCITY OF PROJECTILE AND ITS DIAMETER
- VELOCITY OF THE PROJECTILE AND SHAPE OF THE ITS TIP
- COMPUTED VS PREDICTED VELOCITIES
- J-R UNDERESTIMATES DIAMETER DEPENDENCE AT THESE HIGHER VELOCITIES

FUTURE PLANS

- **COMPUTATIONS USING VARIOUS ZONE SIZES**
- **RUN COMPUTATIONS USING DIFFERENT MATERIAL OF THE PROJECTILE**
- **CHANGE THE ANGLE OF ATTACK**
- **TRANSITION FROM 2-D TO 3-D**